lec. 3

- **ACID** is a substane that can release hydrogen ions [protons H^+].
- **BASE** is a substance that can accept hydrogen ions.
- **PH** is the concentration of hydrogen ions it determines the acidity of the solution. * why we use the pH not the $[H^+]$ concentration?! because the pH is easier to remember and easier to calculate and work with.
- The PH of a solution is the negative base 10 logarithum of its hydrogen ion concentration.

$$\sim PH = -\log_{10}[H^+] \sim \quad [H^+] = 10^{-PH}$$

1	2	3	4	5	6	7	8	9	10	11	12	13	14	PH
10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}	10^{-7}	10^{-8}	10^{-9}	10^{-10}	10^{-11}	10^{-12}	10^{-13}	10^{-14}	$[H^+]$ (mol/L)

← Increasing acidity —— Neutral —— Increasing alkalinity →

PH Inverse relationship with $[H^+]$.

~ How to calculate the PH of acidic and basic solutions ?!

Ex: what is the PH of a solution whose hydrogen ion concentration is 3.2×10^{-4} mol/L ?!

$$\sim PH = -\log [H^+] \sim$$
$$= -\log (3.2 \times 10^{-4})$$
$$= -\log (3.2) - \log (10^{-4})$$
$$= -0.5 + 4$$
$$PH = 3.5$$

- Dissociation Constants (ka)

✓ The tendency ميل of any acid (HA) to lose a proton and form its conjugate المترافقة base (A^-) is called [dissociation constants (ka)].

✓ when an acid loses a proton, its conjugate base is formed.

$HA \rightleftharpoons A^- + H^+$ — $ka = \frac{[A^-]}{[HA]}$

HA: Acid; A^-: Conjugate Base.

* The stronger the acid, the greater its tendency to lose its proton.
* Strong acids are acids that dissociate completely in solution.

  $HCl \longrightarrow Cl^- + H^+$ - In the solution we will find ($Cl^- + H^+$) conjugate base and proton.

  مدى محدود
* Weak acids are acids that dissociate only to a limited extant.

  $H_2CO_3 \longrightarrow HCO_3^- + H^+$ - In the solution we will find [acid + conjugate base, and proton].
* The weak acid ~ Proton donor ~ dissociates into a hydrogen ion (H^+) and an anionic component (A^-), called the ~ Conjugate base (or salt). ~

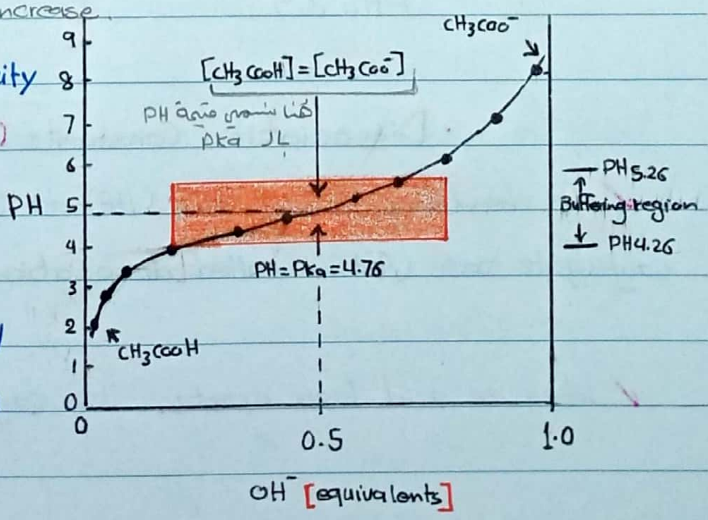
~ PKa ~

- $Pka = -\log ka$ — the acid dissociate to base so half of the acid dissociate to base and half remaind as acid.
- Pka is the pH at which 50% dissociation occurs.
- Pka value is easier to work with and remember than ka value. Pka↑ ka↓
- The stronger the tendency of an acid to dissociate the higher is the ka and the lower is its Pka.

  * كلما كان حمض أقوى للتفكك كلما ka↑ و Pka↓

- PH increase, the dissociation (تفكك) of acid increases thus the concentration of the acid decreases and the ↑ concentration conjugate base increase.

- The maximum buffering capacity exists when the PH of the solution equals the Pka of the buffer, [conjugate base] = [acid], the buffer can then respond equally to both added acid and added base.



[Buffers]

- A buffer is a solution that resists PH changes when acids or bases are added to the solution. تقاوم
- Buffer solutions consist of a weak acid [undissociated acid] and its conjugate base (the form of the acid having lost its Proton).

$$\underset{\text{Acid}}{HA} \rightleftharpoons \underset{\text{Conjugate base}}{A^-} + H^+$$

- A buffer works because added acids (H^+) are neutralized by the conjugate base (A^+) which is converted to the acid (HA).
- Added bases are neutralized by the acid (HA), which is converted to the conjugate base (A^-).
- Two factors determine the effectiveness of a buffer فعالية

1- its Pka relative to the PH of the solution. نسبة

2- its concentration.

– Henderson - Hasselbalch Equation –

- adjusted equation معادلة معدلة shown below describe the relationship between the acid and its conjugate base with PH and pka.

$$\left(PH = Pka + \log \frac{A^-}{HA}\right) \rightarrow \left(PH = Pka + \log_{10} \frac{[\text{Conjugate Base}]}{[\text{Acid}]}\right).$$

- The most effective buffers is when PH = Pka means it has equal concentrations of acid [HA] and its conjugate base [A^-] (50% of both forms AH & A^- present in solution).

$[A^-] = [HA] = 1$

$PH = Pka + \cancel{\log \frac{1}{1}}$

$\boxed{PH = Pka}$

- At $(PH = Pka \pm 1)$ the buffer capacity falls to 33% of the maximum value. Therefore the buffer is effective one point up or down the pH pka value. $\boxed{PH \neq Pka}$ عند إما acid أو base هيكون تركيزه أعلى من الثاني

- if PH less than pka, the concentration of acid higher than concentration of base → والعكس صحيح

– Chemical bonds –

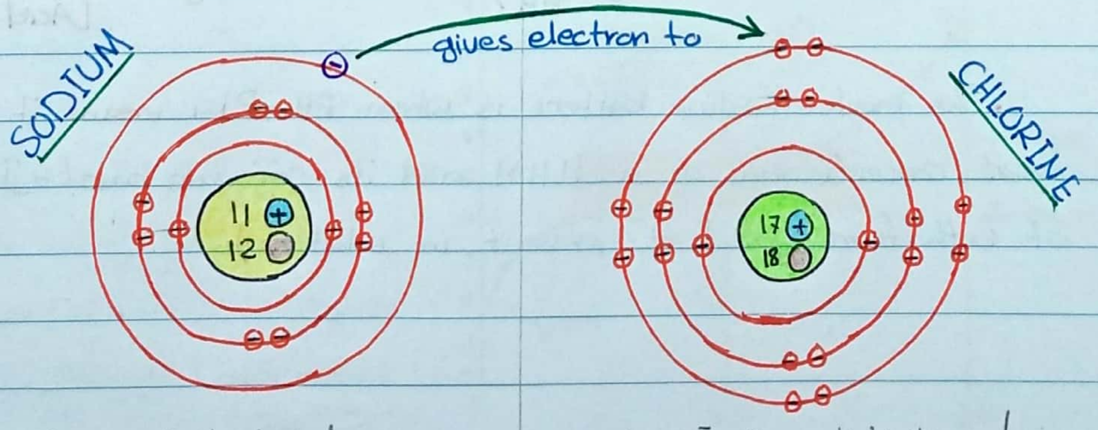
- Refers to the attractive forces that hold atoms together in compounds.
- chemically, bonding occurs when an atom give up electrons, accept electrons, or share electrons with another atom.
- A stable compound occurs when the total energy of the combination has lower energy than the separated atoms.

[Major Bonds in Biological Molecules]

(1) Ionic bonding (2) Covalent bonding (3) Hydrogen bond (4) HydroPhobic Interactions.

(1) Ionic bonding

- electrons are completely transferred from one atom to another.
- The oppositely charged ions are attracted to each other by electrostatic forces, which are the basis of the ionic bond.



- loses ē → positivily charged

- gain $1e^-$ or accept → negativly charged.

- Ionic compounds common features :

1- form between metals and non-metals.

2- In naming simple ionic compounds, the metal is always first, the non-metal second ~ Ex: (Sodium chloride)

metal non-metal

3- dissolve easily in water and other polar solvents.

4- In solution, ionic compounds easily conduct electricity.

5- Tend to form crystalline solids with high melting temperatures

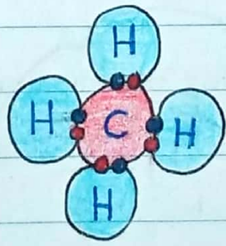
(2) Covalent bonding

- results from sharing one or more electron pairs between two atoms.

- occurs because the atoms in the compound have a similar tendency for electrons (generally to gain electrons).

- The elements involved will share electrons in an effort to fill their valence shells.

- Covalent bonding in carbon -



- Electron from hydrogen.
- Electron from carbon.

~ Covalent Bond ~

1- Polar covalent bonds.

2- NonPolar covalent bonds.

1- Polar covalent bonds result when electrons are unequally shared between atoms [formed between atoms with different electronegativity].

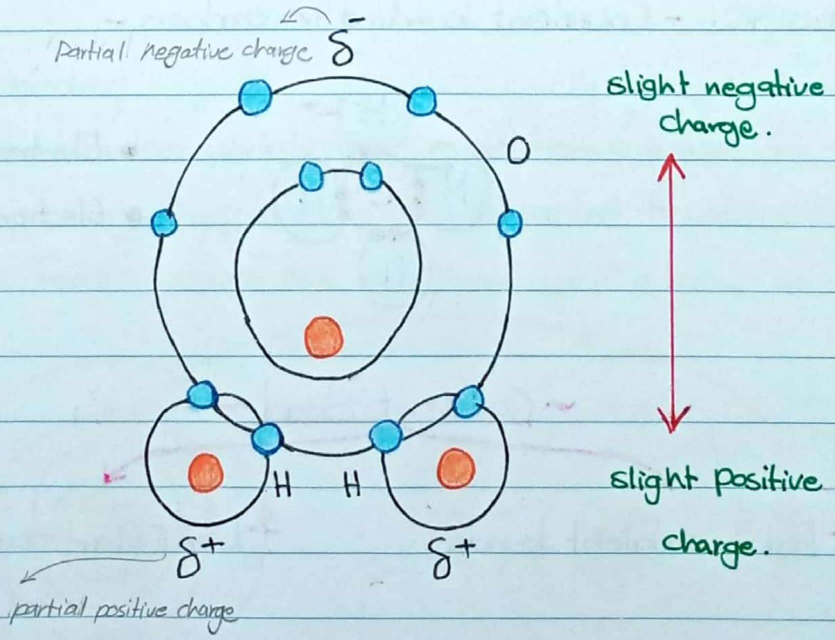
2- Non Polar covalent bonds result when electrons are equally التساوي shared between atoms [formed between atoms with the same electronegativity].

- Electronegativity is the ability of an atom to attract electrons towards itself in a covalent bond.

- Polar covalent bonding occurs because one atom has a stronger affinity تقارب اقوى للالكترونات for electrons (electronegativity) than the other.

- In a Polar covalent bond, the bonding electrons will spend a greater amount of time around the atom that has the stronger affinity for electrons.

- Polar bond in water molecule. the large oxygen atom has a stronger affinity for electrons than the small hydrogen atoms.



* The Electronegativities of Selected Elements. الكهروسلبية

P	H	C	N	O	F
2.1	2.1	2.5	3.0	3.5	4.0
	K	Na	Ca	Mg	Cl
	0.8	0.9	1.0	1.2	3.0

1- $\boxed{Na-Cl}$ 3-0.9= 2.1 Ionic.

2- $\boxed{C-H}$ 2.5-2.1 = 0.4 non-polar

3- $\boxed{H-O}$ 3.5-2.1= 1.4 polar

* If the electronegativity difference between two atoms is less than about 0.5 it will be essentially [non-Polar] and if the difference is 0.5 and less than 2 it is [Polar] and if the difference is greater than 2.0 it is often considered to be [Ionic].

3- Hydrogen bond

- Hydrogen bond is the attractive interaction of a hydrogen atom which covalently bonded to electronegative atom with an electronegative atom like nitrogen, oxygen or fluorine.

• The Partial positive region of hydrogen is attracted to the Partial negative region of another molecule. جزئية

• The hydrogen must be covalently bonded to another electronegative atom to create the bond.

• The hydrogen bond is stronger than a Van der Waals interaction, but weaker than covalent and ionic bonds.

← راجع الصور في السلايد

4- Hydrophobic Interactions

- Nonpolar groups do not form hydrogen bond to water so the are insoluble in water. Ex:- [oil, wax, fat, lipid]
- Hydrophobic substances are "excluded" استبعاد from aqueous مائي solution this drive يدفع these molecules to cluster التجمع together.
- No affinity between nonpolar substances except باستثناء Van der Waals forces that promote تعزز the weak bonding of nonpolar substances.

• Van der waals forces.

✓ are weak attractive forces between electrically neutral atoms or molecules.

✓ They are much weaker than the ionic bond or the Covalent bond.

✓ These forces may develop because the rapid shifting التحول السريع of electrons within molecules causes تسبب some parts of the molecule to become momentarily charged مشحونة مؤقتًا, either positively or negatively.

✓ for this reason, weak, transient العابرة forces of attraction can develop between particles that are actually neutral.

The magnitude حجم القوى of the forces is dependent تعتمد on the distance between neighbouring molecules. المسافات بين الجزيئات المجاورة